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Gas conduit, particularly for an internal combustion engine

The invention relates to a gas conduit having the features of the preamble of claim 1 and to an internal combustion engine having the features of the preamble of claim 11.

German patent DE 100 48 286 has described a gas conduit section which is designed in particular as an exhaust manifold for an internal combustion engine. The exhaust manifold is coated on its inner wall with a material with an adsorbing action, for example based on zeolite. This material can adsorb hydrocarbons (HC), with the result that at least some of the hydrocarbons contained in the exhaust gas can be removed from the exhaust gas during a cold start of the internal combustion engine. The coating does not perform any other functions. The coated conduit section is formed by the exhaust manifold and a conduit piece located upstream of a catalytic converter. However, exhaust manifolds are often exposed to high and rapidly changing temperatures. This imposes very high demands on a coating which is applied direct to the inner wall, in particular if the coating is to be prevented from flaking.

By contrast, it is an object of the invention to provide a gas conduit with improved adsorption and mechanical properties. Furthermore, it is an object of the invention to provide an internal combustion engine with low pollutant emissions.

According to the invention, this object is achieved by a conduit having the features of claim 1 and via an internal combustion engine having the features of claim 11.

The conduit section according to the invention is distinguished by the fact that it has a porous inlay which at least partially bears against its inner wall and forms a hollow body through which gas can flow freely. The inlay may be of single-part or multi-part design and preferably covers the inner wall of the conduit section completely or at least predominantly. The inlay is preferably designed as a dimensionally stable, porous inlay body. By way of example, a porous metal foam body or ceramic foam body is advantageous. The base material may additionally be of closed-cell design. Since foam bodies of this type have a low density, the inlay makes scarcely any contribution to the mass of a conduit section produced from metal. However, the inlay may also be designed as a mat which is pressed onto the inner wall of the conduit section with the aid of a supporting grid. This mat may in this case be formed from a woven or knitted fabric. The hollow body formed by the inlay preferably leaves the majority of the cross section of the conduit section clear, so that the passage of gas is not impeded. An inlay designed in this way provides the conduit section with an action whereby it absorbs and/or adsorbs readily condensable gas constituents.

If the conduit according to the invention is used in the exhaust system of an internal combustion engine, it is possible to adsorb HC constituents in the exhaust gas until a downstream catalytic converter has reached its active operating point. Furthermore, water vapor, which may already have condensed to mist, can be retained for a period of time. This has the advantage that in the event of a cold start of the internal combustion engine, a sensor arranged downstream of the conduit section according to the invention can be heated immediately without being at risk from the phenomenon known as water shock.

A further advantage of an inlay of this type is a silencing action, so that acoustic vibrations of the gas flowing through the conduit section do not penetrate to the outside.

In one configuration of the invention, the inlay is formed from a sintered shaped body that is able to withstand high temperatures. In this context, the term able to withstand high temperatures is to be understood as meaning thermal stability up to approximately 800°C or above. This embodiment is particularly suitable for an exhaust manifold of an internal combustion engine, since the manifold is exposed to high temperatures. It is preferable for the sintered shaped body to be designed as a two-part shell body. For assembly, therefore, the parts of the sintered shaped body can be placed into the halves of an exhaust manifold comprising two half-shells and if appropriate bonded in place, for example by a ceramic adhesive. After the half-shells have been joined together and the joining seam closed up, the result is an exhaust manifold with a high silencing action.

In a further configuration of the invention, the sintered shaped body is formed predominantly from sintered material particles in fiber form. The fibers may, for example, be incorporated into a metal grid, with the result that the sintered shaped body, although dimensionally stable under the action of low forces, can be deformed and matched to the internal contour of the conduit section in the event of stronger forces acting on it. The fibrous nature of the base material gives the sintered shaped body a porous structure with a high surface area. This results in a high adsorption capacity and a high silencing action on the part of the conduit section.

In a further configuration of the invention, the sintered shaped body is formed predominantly from sintered material particles which are approximately spherical in form. This embodiment produces a sintered shaped body with a good dimensional stability and a large number of open pores, since the spheres of the sintered material, which are preferably only slightly deformed during the sintering operation, in the sintered state form a large number of interconnected cavities. It is preferable for the base material itself, from which the sintered material particles are formed, to be porous. The base material may be of metallic or ceramic origin. The spherical shape of the base material produces a sintered shaped body which is of both closed-cell and open-cell configuration. The porosity is then preferably bimodal, i.e. there are two maxima in the pore radius distribution. The result is a good adsorption action for a wide range of hydrocarbons.

In a further configuration of the invention, the sintered shaped body is formed predominantly from sintered material particles in the form of hollow spheres. This embodiment produces a sintered shaped body with a particularly low density and, in addition, heat-insulating properties.

In a further configuration of the invention, the sintered material particles have an external diameter in the range from 0.1 mm to 10 mm, in particular in the range from 0.5 mm to 2 mm. A sintered shaped body produced from sintered material spheres of this type has a high dimensional stability and also a high silencing and adsorbing action.

In a further configuration of the invention, the sintered material particles have a wall thickness which is in the range from 1% to 20%, in particular in the

range from 2% to 5%, of the external diameter. This produces a relatively low density of the sintered shaped body while retaining the other advantages. A density of approximately 0.5 g/cm^3 is preferably achieved.

In a further configuration of the invention, the sintered material is predominantly metallic. This results in relatively low sintering temperatures. The metallic starting material, preferably stainless steel, has a certain ductility, making the sintered shaped body relatively simple to produce. The sintered shaped body formed in this way is moreover easier to machine than sintered shaped bodies made from ceramic material.

In a further configuration of the invention, the sintered material has a porosity in the range from 1% to 30%, in particular in the range from 2% to 5%. This results in advantageous properties with regard to the adsorption of hydrocarbons and water vapor.

This in turn results in low pollutant emissions from the internal combustion engine, in particular during a cold start or when it is warming up.

In a further configuration of the invention, the sintered shaped body has a catalytically active coating. Any standard catalytic coating can be used. It is preferable for the coating to have an oxidation-catalyzing action. If an exhaust manifold is designed as a conduit section of this type, it is possible to dispense with a separate oxidation catalytic converter or at least to make such a converter smaller.

The internal combustion engine according to the invention is distinguished by the fact that the associated exhaust system, upstream of the exhaust-gas catalytic converter, comprises a conduit section as

claimed in one of claims 1 to 11, in particular a conduit section having a porous sintered shaped body which at least partially bears against the inner wall of the conduit section and through which gas can flow freely. The sintered shaped body is preferably produced predominantly from an open-cell and/or closed-cell material. On account of this structure, the conduit section has adsorption properties, and readily condensable exhaust constituents can be retained by the sintered shaped body for a certain period of time during a cold start of the internal combustion engine. It is preferable for the sintered shaped body to be designed in such a way, for example with regard to its material thickness, that condensable hydrocarbons or water vapor are retained in the exhaust gas until the exhaust-gas catalytic converter located further downstream has heated up and become active. The harmful exhaust-gas constituents which are then desorbed from the sintered shaped body can then be effectively converted by the catalytic converter. This results in reduced emission of pollutants, in particular during a cold start and when the internal combustion engine is warming up.

In the text which follows, the invention is explained in more detail on the basis of drawings and associated examples, in which:

Fig. 1 shows an exhaust manifold of an internal combustion engine,

Fig. 2 shows a cross section through a connection of the exhaust manifold, and

Fig. 3 shows an enlarged excerpt from the edge region of the exhaust manifold illustrated in section.

Fig. 1 illustrates an exhaust manifold 1 for a three-cylinder bank of an internal combustion engine designed as a V engine. The exhaust gas which emerges from the three cylinders of the cylinder bank is combined, via three branches of the exhaust manifold, in a common conduit connection in order to be passed onward into the exhaust system. A section line through the conduit connection is denoted by II-II, and the corresponding cross-sectional view is illustrated in Fig. 2 (cf. below). The exhaust manifold 1 is in this case produced from two half-shells, although this is not illustrated in the figure. A prefabricated sintered shaped body (not shown separately here) is placed into each of the half-shells of the exhaust manifold 1. This sintered shaped body has the approximate contours of the associated half-shell and therefore at least predominantly bears against the inner wall of the exhaust manifold. To improve fixing, the sintered shaped body can be bonded into the half-shell, for example by a thermally stable ceramic adhesive. The sintered shaped body has a continuous material thickness of approximately 15 mm. After the sintered shaped bodies have been put in place, the half-shells of the exhaust manifold 1 are joined together and the seams welded. The exhaust manifold is therefore provided with a lining which forms a hollow body through which gas can flow freely and which leaves clear the majority of the cross-sectional area.

Fig. 2 shows a diagrammatic cross-sectional view of that part of the exhaust manifold which ends in a connection for an exhaust pipe, corresponding to section line II-II indicated in Fig. 1. The inserted sintered shaped body 2 or the inserted parts of the sintered shaped body 2 bear against the inner wall of the exhaust manifold connection and cover the inner wall surface of the exhaust manifold 1 completely or at least approximately completely. The join between the

half-shells of the exhaust manifold 1 and the inserted sintered shaped bodies 2 are not illustrated in this figure. III indicates an excerpt from the edge region of the connection of the exhaust manifold 1.

Fig. 3 provides an enlarged and simplified illustration of an excerpt, corresponding to the edge region denoted by III in Fig. 2, of the connection of the exhaust manifold 1 illustrated in section in Fig. 2. As can be seen from the schematic illustration, the sintered shaped body 2 is formed from hollow spheres which have been sintered together. The hollow spheres have an external diameter of approximately 1.5 mm and are made from stainless steel. The wall thickness of the hollow spheres is approximately 0.02 mm, resulting in a structure density of the sintered shaped body 2 of approximately 0.5 g/cm^3. Consequently, the sintered shaped body 2 has a low mass. Cavities are produced between the sintered-together hollow spheres, so as to form a porous structure. In the event of strong sintering, there are scarcely any connections between the cavities of the spheres, resulting in a predominantly closed-cell structure. However, it is preferable for the spheres to be sintered together to a lesser extent, so that an open-cell structure is formed by the spheres. Since the stainless steel used here itself has a certain porosity, the cavities in the interior of the spheres nevertheless also form a closed-cell structure. Therefore, the sintered shaped body 2 has a bimodal pore structure with a porosity in the range from 1% to 30%.

On account of its structure, the sintered shaped body has a silencing action and also, on account of its relatively low thermal conductivity, a thermally insulating action.

In detail, the following advantages result from the

physical properties of the sintered shaped body 2 formed from the sintered shaped body inlay in the exhaust manifold 1. In the event of a cold start by the internal combustion engine, water and unburnt hydrocarbons are adsorbed by or in the sintered shaped body 2. Consequently, the emission of hydrocarbons in the cold-start and warm-up phase of the internal combustion engine is low. As the internal combustion engine warms up further, the catalytic converter (not shown) arranged downstream of the exhaust manifold 1 in the exhaust pipe is also heated. This is accelerated by the fact that water contained in the exhaust gas during the cold start is at least partially adsorbed by the sintered shaped body 2 and is therefore no longer taken up by the catalytic converter. Consequently, the heating of the catalytic converter is not delayed by the evaporation of water that is adsorbed there. Since, moreover, no hydrocarbons or only very small quantities of hydrocarbons reach the catalytic converter during the cold-start phase, the catalytically active centers of the catalytic converter are not deactivated by being occupied by hydrocarbons. Consequently, during the warm-up phase of the internal combustion engine, the catalytic converter reaches its light-off temperature earlier and is therefore available for exhaust-gas purification at an earlier stage. The efficiency of the catalytic exhaust-gas purification can be increased still further if the sintered shaped body 2 is itself coated with a catalytically active material.

As heating continues, hydrocarbons and water adsorbed by the sintered shaped body 2 are released again. However, since the downstream catalytic converter is now active, the hydrocarbons released can be converted in the catalytic converter. The relatively low thermal conductivity of the sintered shaped body 2 also prevents the thermal energy which is introduced into the exhaust gas from being used up to an excessive

extent to heat the conduits which carry exhaust gas. Consequently, the heating of the exhaust pipe system upstream of the catalytic converter and therefore the heating of the catalytic converter are promoted by the sintered shaped body 2.

The ability of the sintered shaped body to adsorb water prevents the possibility of water condensing out downstream of the exhaust manifold 1. If condensed water droplets come into contact with a heated exhaust-gas sensor, this can damage the sensor as a result of the phenomenon known as water shock. An exhaust-gas sensor arranged on the entry side of the catalytic converter close to the internal combustion engine can consequently be heated at a very early stage without being damaged by water shock. Consequently, the exhaust-gas sensor is available at an early time, for example for controlling the mix in the internal combustion engine. Therefore, the use of the exhaust manifold configured in accordance with the invention in this way also improves the emissions from the internal combustion engine during a cold start or when the engine is warming up.

It will be understood that the porous inlay according to the invention is not restricted to being arranged on an exhaust manifold, but rather may also be arranged in another gas conduit section of an internal combustion engine. However, it is preferable for the porous inlay according to the invention to be used in the exhaust system of an internal combustion engine.